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INTERSPECIFIC TRANSMISSION OF MOSAIC DISEASES OF PLANTS

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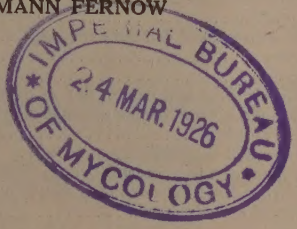

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INTERSPECIFIC TRANSMISSION OF MOSAIC DISEASES OF PLANTS[1]

KARL HERMANN FERNOW

The subject of mosaic diseases is one of great and increasing importance in plant pathology. A large number of economic plants and many wild species are known to be affected. The question of the intercommunicability of mosaic diseases among different suscepts is still largely an unanswered one. Many reports in literature on attempts to transmit them are merely incidental to other investigations, and leave the reader in doubt as to the methods employed and as to the extent of the experimental work on which conclusions are based. In many cases reports of different investigators are in conflict.

The purpose of the studies here reported is to determine: (1) whether the mosaics of different plants are due to distinct causes, here called *viri*, or whether all are due to a single virus; (2) if the causes are several, what plants are affected by each; and (3) what are the symptoms produced by the different viri on various suscepts. Obviously it is impossible to fully answer the above questions in an inquiry as brief as this.

The experiments described were carried on in the greenhouses of the Department of Plant Pathology at Cornell University, and on the experimental farm, during the years 1922, 1923, and 1924.

ACCOUNT OF EXPERIMENTAL WORK

MATERIALS

Source of inoculum

For the sake of convenience, the various sources of inoculum are designated by the letters A to H. As is shown later, these different sources represent also different viri, at least in part. The original sources of the inoculum designated by these letters were respectively as follows:

A. Juice of mosaic tobacco plants kept in a bottle in the greenhouse for several years but still found to be infective.

B. Mosaic potato plants grown from tubers collected in the field in various parts of New York. Also, plants grown from tubers sent to the writer by Dr. Donald Folsom, of Maine, which represent the various types of mosaic described by Schultz and Folsom (1923). Although these

[1] Also presented to the Faculty of the Graduate School of Cornell University, June, 1925, as a major thesis in partial fulfillment of the requirements for the degree of doctor of philosophy.

types appear very different on the potato, the writer was not able to distinguish any difference in the symptoms on other species when inoculated from potato.

C. Mosaic *Datura Stramonium* L. plants sent to the writer by Dr. A. F. Blakeslee from Long Island.

D. A *Nicotiana glutinosa* L. plant which developed mosaic after inoculation from a *Datura Stramonium* plant affected with mosaic C. While this would seem to indicate that mosaics C and D are identical, the data on this point are rather inconclusive and it seems better to regard these mosaics as distinct until proof can be furnished that they are identical.

E. *Phytolacca decandra* L. plants grown from roots of mosaic plants dug near Tully, New York. In all cases the inoculum was taken from the original plants.

F. Mosaic *Rumex obtusifolius* L. plants found near Ithaca and transplanted to the greenhouse.

G. Mosaic *Phaseolus vulgaris* L. plants grown in the greenhouse from infected seed. Inoculum for the field experiments was taken from plants of unknown variety growing in experimental plots.

H. Mosaic *Echinocystis lobata* (Michx.) Torr. & Gray plants growing outdoors in Ithaca.

Plants inoculated

The species selected for inoculation were chosen for various reasons. Some were used because of their relationship to affected plants available, or because of mention in literature. It was naturally impossible to work with a large variety of species. Certain species were discarded because of difficulty of culture or the failure to obtain infection.

Except in the case of potatoes, all the plants used were grown from seed. Special efforts were made to keep the plants growing vigorously by frequent repotting. It was found that some species grew so slowly in the short days of winter that they were not satisfactory for inoculation.

The only inoculations made out of doors were made in the summer of 1923. The plants were started in the greenhouse and transplanted to the field, being spaced three feet each way and one row of sixty-six plants of each species being grown. Some species were repeated.

It was thought that more reliance could be placed on results obtained repeatedly with a relatively small number of plants, than on results obtained with a larger number of plants all inoculated on one date. It seemed desirable also to make the inoculations with different mosaics on the same species on the same date, so that the results would be comparable. As space did not permit the growing of very large numbers of one species at one time, it was necessary to reduce the number of plants in each experiment. In some cases this was doubtless carried to too great an extreme, as when a single plant was inoculated from each source

of inoculum. From three to five plants were inoculated from each source of inoculum at one time in most of the greenhouse experiments, and six or seven plants were used in each experiment in the field.

Generally, as many checks were left as there were plants inoculated with each source of inoculum. The checks were usually treated in the same manner as the inoculated plants, except that a leaf of the check plant itself was substituted for the inoculum. With potatoes, the procedure was different. In planting, a tuber was cut in several (from 4 to 10) pieces and planted in as many pots, each being given the same number but a different letter. All the plants except one were used in inoculation experiments. This one was saved as a check for freedom from disease of the whole unit. For the most part, these were the only checks used for potatoes. The second vegetative generation was always grown when tubers could be obtained. In most of the inoculations made on potatoes, the plants included in any one experiment were taken from different tuber units.

METHODS OF INOCULATION

Rubbing

The method of inoculation used in most of the earlier experiments was as follows: A mosaic leaf was crushed in the hands into a little ball. A leaf of the plant to be inoculated was held in the left hand and vigorously rubbed with the crushed tissue held in the right hand. Sometimes the inoculation was made with one hand only, rubbing the leaf and the inoculum together between the thumb and the forefinger. The rubbing was vigorous enough to break the epidermis of the leaf and was repeated on several leaves of each plant inoculated. Under these conditions the method was found very effective. The hands were freed from infective material by washing with soap, as recommended by Allard (1917).

A variation of this method consisted in the wearing of rubber gloves. The gloves were disinfected by soaking in 10-per-cent formalin for about five minutes. This method was soon abandoned.

The method first described was likewise abandoned early in the course of the experiments, in favor of the following: Two pairs of forceps were used, one with curved points and one with broad flattened points. The forceps were flamed and then used to fold the leaf several times. The inoculum was then held in the curved forceps and rubbed on the leaf to be inoculated, which was supported from behind by the flat-pointed forceps.

In the later experiments the inoculum was sometimes ground in a mortar, which had been disinfected by standing in sulfuric acid and rinsed in water. In this case a knife blade was generally substituted for the flat-pointed forceps, as a support for the inoculated leaf.

Split-stem method

In a few experiments, a slit was made in the stem of the plant to be inoculated, and crushed mosaic leaf tissue was inserted. Flamed instruments were used. This method, however, was found less effective than rubbing.

Grafting

When other methods fail, positive results may sometimes be obtained by grafting. This method was used especially with potatoes. There are, however, several drawbacks. The method is laborious; the scion often fails to live, and, even if it does live, it usually makes but little growth; inoculum carried on the hands or on the knife may be accidentally introduced; furthermore, only those species can be grafted which are closely related. The procedure found most satisfactory was that known as bottle grafting (Blakeslee and Farnham, 1923). This is essentially inarching, the lower end of the scion being placed in a shell vial containing water to prevent drying out.

Comparison of different methods

It was soon found that the methods involving touching the plants with the hands were unsatisfactory because inoculum was thus carried from one experiment to the next. This is well shown in a series of experiments, the results of which are given in table 1. Mosaic material was handled or was placed on the instruments prior to the treatment of each plant. The hands or instruments were then disinfected and the healthy plant was inoculated with its own leaves. The results would seem to indicate that, of the methods of disinfection tried, the flaming of instruments was the only dependable one. The results would seem to indicate also that the method of inoculation involving the placing of inoculum in a slit

TABLE 1. INOCULATION OF TOBACCO PLANTS BY DIFFERENT METHODS

Inoculum	Methods		Number of plants inoculated	Results
	Inoculation	Disinfection		
Mosaic	Hands	None	2	All mosaic
Own leaves	Hands	Soap	4	All mosaic
Mosaic	Rubber gloves	None	4	All mosaic
Own leaves	Rubber gloves	10-per-cent formalin, 2 minutes	2	All mosaic
Own leaves	Rubber gloves	10-per-cent formalin, 5 minutes	3	2 mosaic
Own leaves	Rubber gloves	10-per-cent formalin, 10 minutes	1	All mosaic
Mosaic	Stem slit		4	All mosaic
Own leaves	Stem slit	Flame	4	All healthy

in the stem was effective. Subsequent experiments showed this method to be less reliable, as well as more cumbersome, than the rubbing method.

As a rule, the instruments were disinfected after inoculation of each plant. By this procedure, if one of the inoculated plants was already affected with mosaic without showing the symptoms, the disease would not be carried from this plant to the others. In some cases in which larger numbers of plants were used, the instruments were flamed only after inoculation of two or three plants. In the earlier grafting experiments, mosaic might have been carried from plant to plant by the razor used in grafting; but later this danger was obviated by using safety-razor blades and discarding the blades after they had been used on one plant.

RECORDS

For the purpose of keeping records, all the plants of one species inoculated with the same source of inoculum at one time were assigned a number. Each plant was given a letter to distinguish it from the other plants of the same experiment. The plants were examined almost daily, and a record was kept of the first symptoms observed on each plant.

DIAGNOSIS

Ordinarily, no method of diagnosis was used other than the visual examination of the plants for symptoms. This method, of course, leaves something to be desired with reference to negative evidence. It is quite possible for the symptoms of a mosaic on a given suscept to be so obscure, at least under some conditions, as to escape detection; in such a case, reinoculation of the original suscept from the plants in question would show that they were carriers. It was unfortunately not found practicable to carry out this method, mainly because the limited space available made it impossible to keep on hand a constant supply of the necessary suscepts in vigorous condition.

It is possible also to err in the other direction, and diagnose as affected by mosaic a plant which has been injured by fumigation, insects, or soil conditions. There may have been isolated instances wherein this mistake was made, but usually mosaic was not recorded unless definite and unmistakable symptoms were present. Extremely doubtful cases were omitted altogether from the tables.

Recognition and description of different mosaics

As already mentioned, the different sources of inoculum produce different effects on the same suscepts. It is convenient at this point to describe the symptoms produced by the different viri on the various species used. In keeping the records of the experiments, it was found desirable to record not only the presence or the absence of mosaic, but

also, in positive cases, to record which mosaic was present. It will readily be understood that the chances of error in this matter are greater than in the simple statement as to whether or not a plant is affected with mosaic. Two mosaics on the same species may be very distinct in their characteristic expression and yet individual cases will occur in which it is difficult or impossible to say with which mosaic one is dealing. In the brief discussions of the various mosaics which follow, it must be borne in mind that the symptoms vary greatly with the conditions, not only in intensity but even in kind. To describe all the possible symptoms that may be produced by each mosaic would require very lengthy descriptions preceded by years of experience. Even the best of such would prove inadequate to the recognition of these mosaics by persons not already acquainted with them. The descriptions are therefore largely comparative, and are presented for the purpose of distinguishing between the various mosaics when two or more are at hand on the same species. It will be found useful to refer to the accompanying plates for more ready comparison.

Datura meteloides Dunal and *D. Stramonium* appear to be subject to both mosaic B and mosaic C. The symptoms of mosaic B (Plate I, 2) are usually rather large irregular areas of yellowish green appearing on the dark green background of the leaf, with little or no rugosity of the leaf. Mosaic C (Plate I, 3), on the other hand, produces a very pronounced rugosity, often causing the leaf to appear blistered, and the leaves are not infrequently narrowed and twisted. The flowers are sometimes distorted, and are generally marked with blue or purple streaks on the purple variety. It is not certain whether the streaking may not occur also in connection with mosaic B.

Lycopersicon esculentum Mill. is affected by both mosaic A and mosaic B. The symptoms of mosaic A (Plate I, 6) are well known, this probably being the mosaic of tomatoes generally referred to in literature. The leaves show rather sharply contrasted areas of dark green and light yellowish green. The mottling is usually most readily detected on the very young leaves. It is often somewhat difficult to detect mosaic on tomato, because of the narrowness of the leaves and the fact that the young leaves are often normally lighter-colored and somewhat distorted. The distortion due to mosaic A is usually greatest in plants that have become infected when very small. In such plants, the blade of the leaf may be almost entirely suppressed, and the filiform leaves much twisted and curled. In artificially inoculated plants, the distortion is generally not so striking.

The symptoms of mosaic B (Plate I, 5) on this plant are much less striking. As the leaves become fully expanded they show a rather ill-defined mottling. The symptoms may be easily mistaken for the effects of soil or water conditions or of unfavorable temperature. As far as observed, the very young leaves show no noticeable symptoms and no

appreciable distortion. The contrast between these two mosaics of tomato is much greater than would appear from an examination of Plate I (4, 5, and 6).

The mosaic on *Martynia louisiana* Mill. shows as a distinct mottling affecting rather large, well-defined patches.

Nicandra Physalodes (L.) Pers. is affected by two mosaics. Mosaic B (Plate II, 8 and 11) produces a distinct mottling consisting of small light areas in the darker leaf. Generally the leaves are not much distorted but often they are somewhat smaller than those of healthy plants and they are sometimes slightly cupped, the edges turning downward. They may be slightly rugose. The flowers are not affected except that they also may be smaller than normal. Mosaic H on *N. Physalodes* (Plate II, 10) produces almost no mottling, but instead one finds a pronounced and characteristic distortion. The leaves develop very irregular lacerated margins and become more pointed. The veins are more prominent and straighter, and branch in a peculiar manner. The flowers are often much affected (Plate III). They are almost always smaller than normal, the sepals often show the peculiarities of venation described for the leaves, and the corolla is often divided. The divisions of the corolla do not always correspond to the normal petal lobes, and may divide it into two or three parts of unequal size.

Three mosaics occur on *Nicotiana glutinosa*. Mosaic B (Plate IV, 17 and 19) causes a fine mottling consisting of light green islands with darker green showing along the smaller veins. Usually the mottling is not very striking under greenhouse conditions, but it may be so in the field where the plants grow rapidly. Mosaic D (Plate IV, 16 and 20) shows as a very faint spotting. There are generally only four or five of these small spots on each leaf. They are usually not clearly outlined and may be evident only by transmitted light. Mosaic H (Plate IV, 14 and 15) is extremely pronounced and distinct, in contrast to the other mosaics occurring on this species. The affected leaves show large contrasted areas of yellowish green, and sometimes dark green blisters, as in the case of the small leaf in Plate IV, 14. The leaves are generally somewhat dwarfed and distorted, and sometimes they are much reduced. The appearance of this mosaic is similar to that of the familiar mosaic on tobacco.

Mosaic A on *Nicotiana rustica* L. (Plate VI) has a striking and unusual effect. The leaves generally turn yellow and then brown near each point of inoculation. The leaves near the growing point then turn yellow, growth ceases, and the terminal bud and the younger leaves die and shrivel up, leaving only the stump and some of the older leaves green. On splitting the stem, it is seen that necrotic spots occur in the interior.

Mosaic A on *Nicotiana Tabacum* L. (the well-known tobacco mosaic) is characterized by a distinct mottling consisting generally of rather

large yellowish green areas intermingled with large patches of dark green. Sometimes the lighter areas predominate, but usually the darker part is more extensive. Sometimes the darker areas appear as blisters. Not infrequently, if the plant is affected early, the leaves may be considerably distorted. The flowers also have been observed to be distorted and abnormally pigmented, as described by Allard (1914).

Mosaic G on *Phaseolus vulgaris* (Plate V, 21) is generally manifested by a mottling consisting of rather large, well-defined patches of light and dark green. The younger leaves are often reduced in size, and cupped.

Mosaic A on *Physalis heterophylla* Nees is similar in appearance to the ordinary tobacco mosaic.

Mosaic A on *Physalis subglabrata* Mackenzie & Bush (Plate II, 12) is also similar in appearance to tobacco mosaic.

Mosaic E on *Phytolacca decandra* is similar in appearance to tobacco mosaic, but the leaves are seldom blistered. The mottled areas are generally large.

Mosaic F on *Rumex obtusifolius* shows as a rather fine, regular mottling, not very striking.

On *Solanum aculeatissimum* Jacq. (Plate V, 22) both mosaic A and mosaic B occur. Neither ordinarily produces striking symptoms, and the writer has thus far been unable to distinguish between them with any degree of certainty. It would appear that the contrasted areas were generally larger for mosaic A than for mosaic B.

Solanum atropurpureum Schrank and *S. carolinense* appear to be subject to both mosaic A and mosaic B. As in the case of *S. aculeatissimum*, the two mosaics are not readily distinguished, but mosaic A seems to produce larger contrasted areas than does mosaic B.

Solanum nigrum L. has reacted positively to mosaic A only, in the few experiments performed. The mosaic produced is rather striking, and resembles mosaic A on tobacco.

Solanum tuberosum L. has been found to be subject to both mosaic A and mosaic B. Inoculations with mosaic A by grafting produce very remarkable symptoms. The young shoots of the potato are affected with what was at first thought to be an attack of early blight. Small yellowish spots show on the leaves. These spots soon die and turn brown. The petioles and the young stems become affected with a severe necrotic streaking and the affected shoots generally die soon after. Sometimes no symptoms appear until the second vegetative generation. The second-generation plants are usually much dwarfed (Plate VII, 25) and the leaves may show from one to five yellowish spots which soon become brown. As these spots often appear before the leaf has fully expanded, and as the affected areas are unable to grow, the leaf develops a puckered appearance. The petioles and stems are often affected with a more severe necrotic streaking than in the first-generation plants, and the older le ves

are dropped, leaving only a small crown. These symptoms closely resemble those described for potato streak by Schultz and Folsom (1923).

Mosaic B was obtained whenever potatoes were used as a source of inoculum on a suitable suscept. This was the case whether the potatoes used showed symptoms of mild, leaf-rolling, or rugose mosaic (Schultz and Folsom, 1923), mosaic A, or some other virus disease. Later the same symptoms were obtained when apparently healthy potatoes were used as sources of inoculum. One is therefore led to the conclusion that the symptoms of the various mosaics mentioned are due not to mosaic B but to other viri, and that the virus of mosaic B produces no visible symptoms on potato.[2]

Time required for the production of symptoms

The length of time after inoculation and before symptoms appeared varied greatly with the suscept, the inoculum, and the environmental conditions. In general, the symptoms appeared most quickly on plants that were growing rapidly. The shortest time recorded was four days; this was for *Nicotiana rustica* inoculated with mosaic A. Other plants showed the first detectable symptoms seven weeks after inoculation, and with potatoes the symptoms were sometimes detected only in the second generation, seven months or more after inoculation. It may be said that the longer periods usually indicate conditions unfavorable for the detection of mosaic, such as slow-growing pot-bound plants or red-spider or thrips injury. Under favorable conditions of temperature and other factors, plants will usually show symptoms within three weeks. In any experiment, the individual plants are likely to show mosaic at about the same time. Plants were therefore generally kept for only a week or so after the first symptoms began to appear.

One would naturally expect to find some difference in the length of time between inoculation and the appearance of symptoms, according to the suscept and the inoculum. It is evident that so many other factors were involved, besides these two, that conclusions drawn from the experiments here reported can be regarded only as approximations. However, the general impression gained from experience is that in most cases the period varies more with the suscept than with the inoculum used, and that there is a considerable personal equation involved; that is to say, one person will recognize the first symptoms more readily than will another, and the same person will recognize early symptoms more readily after some experience with a given mosaic and suscept than at an earlier date in his experience.

When inoculated with mosaic A, *Nicotiana rustica* appears to show symptoms soon, tobacco and *Solanum aculeatissimum* somewhat later,

[2] This phenomenon is discussed at greater length on page 31.

tomato still later, and potato only after a considerable period. When inoculated with mosaic B, *Datura Stramonium, Solanum aculeatissimum, Nicandra Physalodes,* and *Nicotiana glutinosa,* show symptoms readily, while tomato and potato are slower. *Datura Stramonium* seems to show mosaic B more quickly than mosaic C, and *Nicotiana glutinosa* appears to show mosaic B only slightly more quickly than mosaic D. Mosaic H apparently develops very slowly on both *Nicandra Physalodes* and *Nicotiana glutinosa.* However, another investigator with a different point of approach might recognize earlier symptoms on the suscepts here mentioned as slow, or might overlook early symptoms on suscepts here mentioned as showing symptoms early.

SOURCES OF ERROR

Any series of experiments such as is here reported is subject to certain sources of error. The errors may be classified as errors in diagnosis, errors due to accidental contamination, and errors due to the application of methods which are ineffective for the particular disease and species of plants under consideration.

Errors of diagnosis

Errors of diagnosis may be in either direction. There is abundant evidence in literature, as well as in the writer's experience, that plants may, under some conditions, harbor mosaic for long periods without showing any visible symptoms. Such cases are reported for eggplant by Melhus (1922), and for *Physalis Alkekengi* L. by Nishimura (1918). If the plants are kept rapidly growing under favorable conditions, there is less likelihood of error from this cause. The feeling is general among plant pathologists that negative results are of little significance as compared with positive results. While this feeling is justified in general, it must not be forgotten that positive results may also be misleading. Positive results may be reported in the case of plants not actually affected, due to the effects of low or high temperatures, insufficient water, infestation with thrips or red spider, or other conditions, or they may be due to natural infection.

In addition to positive diagnosis of plants affected with mosaic, some attempt should always be made to identify the mosaic concerned. It is evident that very few authors have made any attempt to determine whether all the plants of a given species which they succeeded in artificially infecting were attacked by the same virus. This would necessitate the inoculation of parallel series of plants and a careful comparison of the infected plants. Even when this is done, the chances of an error in the identification of the mosaic are greater than the chances of an error in determining whether the plant in question is affected with mosaic.

Errors due to accidental contamination

There are a number of ways in which contamination may occur. These may be briefly mentioned:

1. The plant used as the source of inoculum may be affected with two or more mosaics.
2. The inoculum may become contaminated during the process of preparing it for use.
3. The instruments (or hands) used in making the inoculation may be contaminated.
4. The inoculated plant may become infected from some source other than the experimental inoculum. Ways in which this may occur are: by insects; by handling by the experimenter or by visitors; by contact of the injured parts of the plants, as the rubbing together of inoculated leaves or the breaking and rubbing of roots in moving the pots; and by the use of plants from previous experiments where symptoms are masked.

Errors due to the use of ineffective methods

It is well within the bounds of possibility that methods which would give good infection with one mosaic or a certain suscept, would fail with a different combination of mosaic and suscept. For example, it is well known that tobacco mosaic can be transmitted by hypodermic injections. Reddick and Stewart (1919) were unable to transmit bean mosaic by this method, although they made many attempts.

RESULTS OF EXPERIMENTS

The results of the inoculations with material from different species are presented in tables 2 to 20. These data are summarized in table 21 with respect to the particular mosaic concerned.

TABLE 2. INOCULATIONS ON DATURA METELOIDES

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Nicotiana Tabacum*	3	0	.....
B	*Solanum tuberosum*	7	5	Uncertain
C	*Datura Stramonium*	7	4	Uncertain
D	*Nicotiana glutinosa*	7	2	Uncertain
E	*Phytolacca decandra*	3	0	.....
F	*Rumex obtusifolius*	5	0	.....
G	*Phaseolus vulgaris*	3	0	.....
H	*Echinocystis lobata*	7	0	.....
Checks	Own leaves	7	0	.....

* For the original source of the mosaic indicated by letters A to H, see pages 3 and 4.

TABLE 3. INOCULATIONS ON DATURA STRAMONIUM

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	6	0	
A	*Nicotiana Tabacum*	11	3	C
A	*Solanum aculeatissimum*	2	0	
B	*Datura Stramonium*	8	8	B
B	*Lycopersicon esculentum*	6	4	B
B	*Nicandra Physalodes*	3	3	B
B	*Nicotiana glutinosa*	8	7	5 B 2 Uncertain
B	*Solanum aculeatissimum*	1	1	B
B	*Solanum atropurpureum*	5	4	Uncertain
B	*Solanum tuberosum*	29	28	20 B 8 Uncertain
C	*Datura Stramonium*	27	20	4 B 10 C 3 B and C 3 Uncertain
C	*Solanum aculeatissimum*	1	1	C
D	*Nicotiana glutinosa*	23	10	9 C 1 Uncertain
E	*Phytolacca decandra*	10	0	
F	*Rumex obtusifolius*	14	0	
G	*Phaseolus vulgaris*	9	0	
H	*Echinocystis lobata*	6	0	
H	*Nicandra Physalodes*	5	0	
H	*Nicotiana glutinosa*	2	0	
Checks		28	0	

* See footnote to table 2, page 13.

TABLE 4. INOCULATIONS ON LYCOPERSICON ESCULENTUM

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	26	24	A
A	*Nicotiana Tabacum*	59	58	A
A	*Solanum nigrum*	2	2	A
A	*Solanum tuberosum*	3	3	A
B	*Lycopersicon esculentum*	6	5	B
B	*Datura Stramonium*	1	0	.....
B	*Solanum tuberosum*	55	41	1 A 27 B 13 Uncertain
C	*Datura Stramonium*	9	0	.....
D	*Nicotiana glutinosa*	7	0	.....
E	*Phytolacca decandra*	3	0	.....
F	*Rumex obtusifolius*	8	0	.....
G	*Phaseolus vulgaris*	3	0	.....
H	*Echinocystis lobata*	7	0	.....
Checks	.....	39	0	.....

* See footnote to table 2, page 13.

TABLE 5. INOCULATIONS ON MARTYNIA LOUISIANA

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Nicotiana Tabacum*	4	4	Uncertain
B	*Solanum tuberosum*	4	0	.....
D	*Nicotiana glutinosa*	4	2	Uncertain
E	*Phytolacca decandra*	5	0	.....
F	*Rumex obtusifolius*	4	0	.....
G	*Phaseolus vulgaris*	4	0	.....

* See footnote to table 2, page 13.

TABLE 6. INOCULATIONS ON NICANDRA PHYSALODES

Mosaic*	Suscept, source of inoculum,	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	11	0	.....
A	*Nicotiana Tabacum*	18	4	B
A	*Solanum aculeatissimum*	6	2	B
B	*Datura Stramonium*	1	1	B
B	*Lycopersicon esculentum*	6	6	B
B	*Nicandra Physalodes*	18	17	B
B	*Nicotiana glutinosa*	3	3	B
B	*Solanum aculeatissimum*	5	5	B
B	*Solanum tuberosum*	116	94	B
C	*Datura Stramonium*	15	0	.....
D	*Nicotiana glutinosa*	16	0	.....
E	*Phytolacca decandra*	7	0	.....
F	*Rumex obtusifolius*	11	0	.....
G	*Phaseolus vulgaris*	7	0	.....
H	*Echinocystis lobata*	17	10	H
H	*Nicandra Physalodes*	14	3	H
H	*Nicotiana glutinosa*	17	3	H
H	*Nicotiana rustica*	2	2	H
Checks	.....	65	1	B

* See footnote to table 2, page 13.

TABLE 7. INOCULATIONS ON NICOTIANA GLUTINOSA

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	4	1	B
A	*Nicotiana Tabacum*	18	0	.....
A	*Solanum aculeatissimum*	4	1	Uncertain
A	*Solanum tuberosum*	2	0	.....
B	*Datura Stramonium*	3	1	B
B	*Nicandra Physalodes*	2	2	B
B	*Nicotiana glutinosa*	4	2	B
B	*Solanum aculeatissimum*	1	1	B
B	*Solanum tuberosum*	52	44	B
C	*Datura Stramonium*	26	3	1 D 2 B 1 B
D	*Nicotiana glutinosa*	37	25	17 D 7 Uncertain
E	*Phytolacca decandra*	8	0	.....
F	*Rumex obtusifolius*	13	0	.....
G	*Phaseolus vulgaris*	7	0	.....
H	*Echinocystis lobata*	7	0	.....
H	*Nicandra Physalodes*	6	4	H
H	*Nicotiana glutinosa*	4	0	.....
Checks	.....	21	0	.....

* See footnote to table 2, page 13.

TABLE 8. INOCULATIONS ON NICOTIANA RUSTICA

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	4	3	A
A	*Nicotiana Tabacum*	27	25	A
A	*Solanum aculeatissimum*	1	0	.....
B	*Datura Stramonium*	2	0	.....
B	*Nicandra Physalodes*	3	0	.....
B	*Nicotiana glutinosa*	3	1	A
B	*Solanum aculeatissimum*	1	0	.....
B	*Solanum tuberosum*	14	0	.....
C	*Datura Stramonium*	12	0	.....
D	*Nicotiana glutinosa*	11	0	.....
E	*Phytolacca decandra*	8	0	.....
F	*Rumex obtusifolius*	11	1	A
G	*Phaseolus vulgaris*	6	0	.....
H	*Echinocystis lobata*	6	0	.....
H	*Nicandra Physalodes*	7	0	.....
H	*Nicotiana glutinosa*	2	0	.....
Checks	.....	23	1	A

* See footnote to table 2, page 13.

DATURA STRAMONIUM AND LYCOPERSICON ESCULENTUM

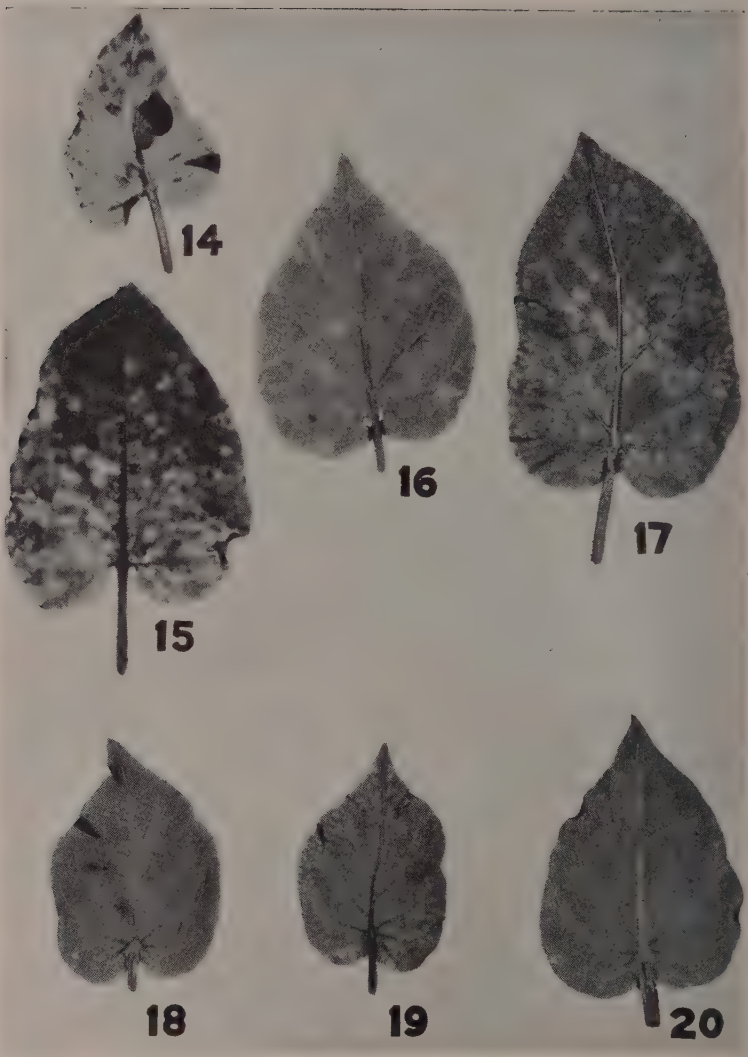
1–3, *Datura Stramonium*: 1, normal leaf; 2, leaf showing mosaic B; 3, leaf showing mosaic C
4–6, *Lycopersicon esculentum*: 4, normal leaf; 5, leaf showing mosaic B; 6, leaf showing mosaic A

NICANDRA PHYSALODES AND PHYSALIS SUBGLABRATA

7–11, *Nicandra Physalodes*: 7 and 9, normal leaves; 8 and 11, leaves showing mosaic B; 10, leaf showing mosaic H
12, *Physalis subglabrata*, top of plant, showing mosaic A

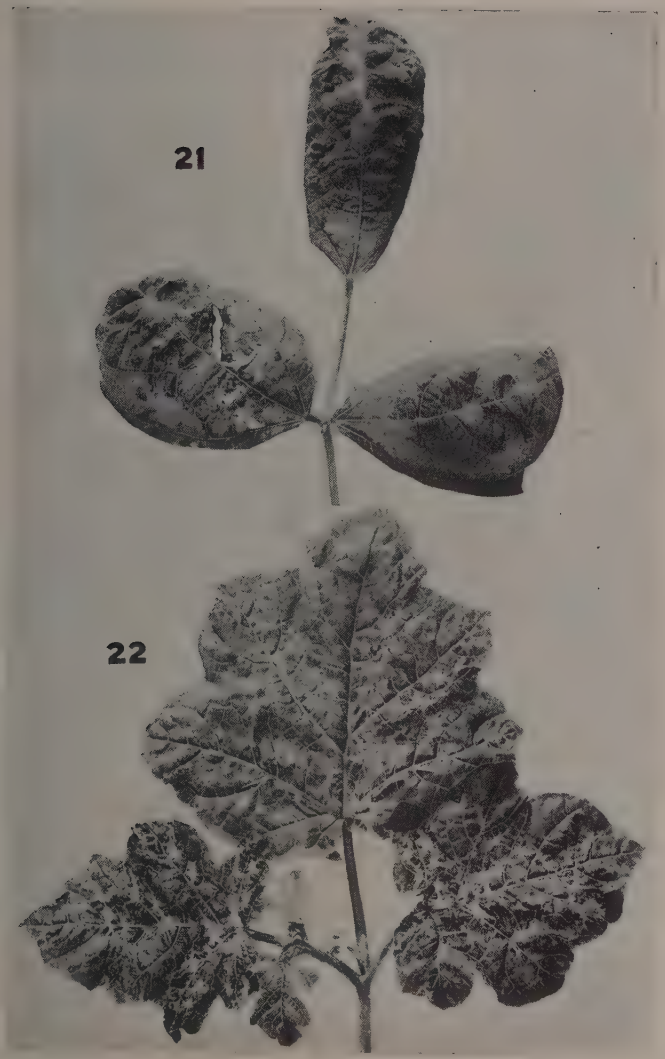
FLOWERS OF NICANDRA PHYSALODES

Flowers in upper row, from plant affected with mosaic H; large flowers below, from normal plant



NICOTIANA GLUTINOSA

14 and 15, Leaves showing mosaic H; 16 and 20, leaves showing mosaic D; 17 and 19, leaves showing mosaic B; 18, normal leaf

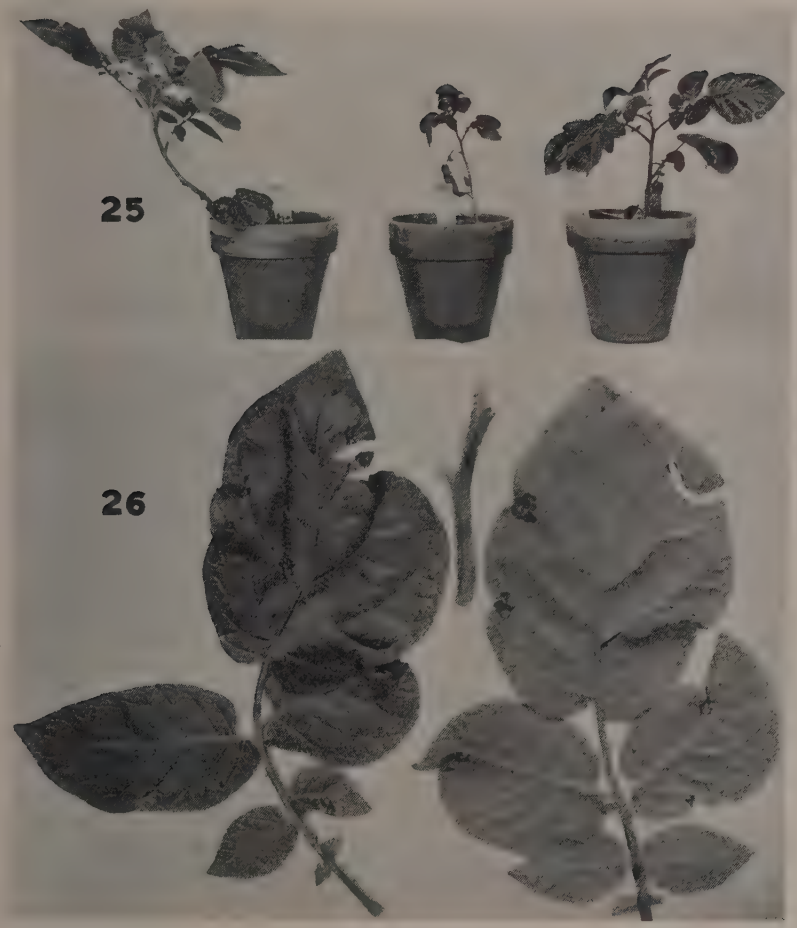


PHASEOLUS VULGARIS AND SOLANUM ACULEATISSIMUM

21, *Phaseolus vulgaris*, leaf showing mosaic G
22, *Solanum aculeatissimum*, leaves showing mosaic A

NICOTIANA RUSTICA

23, Plant showing mosaic A; the areas near the points of inoculation, and the youngest leaves, are dead and brown. 24, Normal plant



SOLANUM TUBEROSUM

25, Plants affected with mosaic A, showing the dropping of the leaves. 26, Leaves, and a part of a stem, from the same plants, showing the puckering around the necrotic spots, and the necrotic streaks on the stem

TABLE 9. INOCULATIONS ON NICOTIANA TABACUM

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	4	4	A
A	*Nicotiana Tabacum*	62	58	A
A	*Martynia louisiana*	3	3	A
A	*Solanum aculeatissimum*	5	4	A
A	*Solanum tuberosum*	30	23	A
B	*Lycopersicon esculentum*	2	1	A
B	*Datura Stramonium*	4	0	.....
B	*Nicandra Physalodes*	4	4	A
B	*Nicotiana glutinosa*	3	0	.....
B	*Solanum aculeatissimum*	6	2	A
B	*Solanum tuberosum*	37	1	A
C	*Datura Stramonium*	10	1	A
D	*Nicotiana glutinosa*	6	1	A
E	*Phytolacca decandra*	9	0	.....
F	*Rumex obtusifolius*	3	0	.....
G	*Phaseolus vulgaris*	3	0	.....
Checks	.....	46	3	A

* See footnote to table 2, page 13.

TABLE 10. INOCULATIONS ON PHASEOLUS VULGARIS

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Nicotiana Tabacum*	6	0	.....
B	*Solanum tuberosum*	6	0	.....
C	*Datura Stramonium*	6	0	.....
D	*Nicotiana glutinosa*	7	0	.....
E	*Phytolacca decandra*	2	0	.....
F	*Rumex obtusifolius*	7	0	.....
G	*Phaseolus vulgaris*	12	3	G
H	*Echinocystis lobata*	6	0	.....
Checks	.....	7	0	.....

* See footnote to table 2, page 13.

TABLE 11. INOCULATIONS ON PHYSALIS HETEROPHYLLA

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Nicotiana Tabacum*	7	7	A
B	*Solanum tuberosum*	8	0	.....
C	*Datura Stramonium*	7	0	.....
D	*Nicotiana glutinosa*	8	0	.....
E	*Phytolacca decandra*	3	0	.....
F	*Rumex obtusifolius*	7	1	A
G	*Phaseolus vulgaris*	3	0	.....
H	*Echinocystis lobata*	7	0	.....
Checks	.....	7	0	.....

* See footnote to table 2, page 13.

TABLE 12. INOCULATIONS ON PHYSALIS SUBGLABRATA

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	2	2	A
A	*Nicotiana Tabacum*	21	21	A
B	*Solanum tuberosum*	24	3	Uncertain
C	*Datura Stramonium*	21	0	.....
D	*Nicotiana glutinosa*	24	0	.....
E	*Phytolacca decandra*	21	0	.....
F	*Rumex obtusifolius*	21	6	Uncertain
G	*Phaseolus vulgaris*	9	0	.....
H	*Echinocystis lobata*	21	0	.....
Checks	.....	23	0	.....

* See footnote to table 2, page 13.

TABLE 13. INOCULATIONS ON PHYTOLACCA DECANDRA

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	2	0	.....
A	*Nicotiana Tabacum*	18	0	.....
A	*Solanum aculeatissimum*	2	0	.....
A	*Solanum tuberosum*	2	0	.....
B	*Datura Stramonium*	2	0	.....
B	*Lycopersicon esculentum*	2	0	.....
B	*Nicandra Physalodes*	5	0	.....
B	*Nicotiana glutinosa*	2	0	.....
B	*Solanum aculeatissimum*	2	0	.....
B	*Solanum tuberosum*	35	0	.....
C	*Datura Stramonium*	16	0	.....
D	*Nicotiana glutinosa*	9	0	.....
E	*Phytolacca decandra*	17	16	E
F	*Rumex obtusifolius*	14	0	.....
G	*Phaseolus vulgaris*	5	0	.....
H	*Echinocystis lobata*	5	0	.....
H	*Nicandra Physalodes*	6	0	.....
Checks	.....	23	0	.....

* See footnote to table 2, page 13.

TABLE 14. INOCULATIONS CN RUMEX OBTUSIFOLIUS

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	2	0	.....
A	*Nicotiana Tabacum*	16	0	.....
B	*Datura Stramonium*	2	0	.....
B	*Nicotiana glutinosa*	2	0	.....
B	*Solanum tuberosum*	19	0	.....
C	*Datura Stramonium*	12	0	.....
D	*Nicotiana glutinosa*	15	0	.....
E	*Phytolacca decandra*	6	0	.....
F	*Rumex obtusifolius*	29	13	F
G	*Phaseolus vulgaris*	3	0	.....
Checks	.....	14	0	.....

* See footnote to table 2, page 13.

TABLE 15. INOCULATIONS ON SOLANUM ACULEATISSIMUM

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	6	5	Uncertain
A	*Nicotiana Tabacum*	32	27	3 A 24 Uncertain
A	*Solanum tuberosum*	7	7	Uncertain
B	*Datura Stramonium*	5	3	Uncertain
B	*Lycopersicon esculentum*	2	2	B
B	*Nicandra Physalodes*	2	2	Uncertain
B	*Nicotiana glutinosa*	5	4	Uncertain
B	*Solanum tuberosum*	35	24	Uncertain
C	*Datura Stramonium*	21	2	1 A 1 Uncertain
D	*Nicotiana glutinosa*	11	0	.....
E	*Phytolacca decandra*	9	0	.....
F	*Rumex obtusifolius*	12	0	.....
G	*Phaseolus vulgaris*	8	0	.....
H	*Echinocystis lobata*	7	0	.....
H	*Nicandra Physalodes*	2	2(?)	H(?)†
Checks	.....	29	0	.....

* See footnote to table 2, page 13.
† The author was not sure that these plants were affected with mosaic. The symptoms were certainly not those of either mosaic A or mosaic B.

TABLE 16. INOCULATIONS ON SOLANUM ATROPURPUREUM

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Nicotiana Tabacum*	3	3	A
B	*Solanum tuberosum*	3	2	B
C	*Datura Stramonium*	3	0	.....
D	*Nicotiana glutinosa*	3	0	.....
F	*Rumex obtusifolius*	3	0	.....
H	*Echinocystis lobata*	2	0	.....
Checks	.....	2	0	.....

* See footnote to table 2, page 13.

TABLE 17. INOCULATIONS ON SOLANUM CAROLINENSE

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	2	2	A
A	*Nicotiana Tabacum*	7	7	A
B	*Solanum tuberosum*	9	6	B
C	*Datura Stramonium*	7	0	.....
D	*Nicotiana glutinosa*	8	0	.....
E	*Phytolacca decandra*	2	0	.....
F	*Rumex obtusifolius*	7	0	.....
G	*Phaseolus vulgaris*	3	0	.....
H	*Echinocystis lobata*	6	0	.....
Checks	.....	9	0	.....

* See footnote to table 2, page 13.

TABLE 18. INOCULATIONS ON SOLANUM DULCAMARA

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	2	0	.....
A	*Nicotiana Tabacum*	7	0	.....
B	*Solanum tuberosum*	9	0	.....
C	*Datura Stramonium*	7	0	.....
D	*Nicotiana glutinosa*	8	0	.....
E	*Phytolacca decandra*	3	0	.....
F	*Rumex obtusifolius*	7	0	.....
G	*Phaseolus vulgaris*	3	0	.....
H	*Echinocystis lobata*	7	0	.....
Checks	.....	9	0	.....

* See footnote to table 2, page 13.

TABLE 19. INOCULATIONS ON SOLANUM NIGRUM

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Nicotiana Tabacum*	9	5	A
B	*Solanum tuberosum*	9	1	A
C	*Datura Stramonium*	7	0	
D	*Nicotiana glutinosa*	8	0	
E	*Phytolacca decandra*	3	0	
F	*Rumex obtusifolius*	7	0	
G	*Phaseolus vulgaris*	3	0	
H	*Echinocystis lobata*	7	0	
Checks		9	1	A

* See footnote to table 2, page 13.

TABLE 20. INOCULATIONS ON SOLANUM TUBEROSUM

Mosaic*	Suscept, source of inoculum	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
A	*Lycopersicon esculentum*	26	22	21 A 1 A and B
A	*Nicotiana Tabacum*	14	2	1 A 1 A and B
B	*Lycopersicon esculentum*	11	9	B
B	*Nicandra Physalodes*	9	0	
B	*Nicotiana glutinosa*	1	0	
B	*Solanum tuberosum*	53	31	B
C	*Datura Stramonium*	2	0	
D	*Nicotiana glutinosa*	1	0	
E	*Phytolacca decandra*	2	0	
F	*Rumex obtusifolius*	2	0	
G	*Phaseolus vulgaris*	1	0	
Checks	Rubbed	6	0	
	Grafted	9	5	4 A 1 B
	Untreated	23	0	

* See footnote to table 2, page 13.

TABLE 21. RESULTS OF INOCULATIONS OF VARIOUS SPECIES WITH VARIOUS MOSAICS
(Summary of tables 2 to 20)

Species inoculated	Mosaic	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
Datura meteloides	A	3	0	.....
	B	7	5	Uncertain
	C	7	4	Uncertain
	D	7	2	Uncertain
	E	3	0	.....
	F	5	0	.....
	G	3	0	.....
	H	7	0	.....
	Checks	7	0	.....
Datura Stramonium	A	19	3	C
	B	60	55	41 B 14 Uncertain
	C	28	21	4 B 11 C 3 B and C 3 Uncertain
	D	23	10	9 C 1 Uncertain
	E	10	0	.....
	F	14	0	.....
	G	9	0	.....
	H	13	0	.....
	Checks	28	0	.....
Lycopersicon esculentum	A	90	87	A
	B	62	46	1 A 32 B 13 Uncertain
	C	9	0	.....
	D	7	0	.....
	E	3	0	.....
	F	8	0	.....
	G	3	0	.....
	H	7	0	.....
	Checks	39	0	.....
Martynia louisiana	A	4	4	Uncertain
	B	4	0	.....
	D	4	2	Uncertain
	E	5	0	.....
	F	4	0	.....
	G	4	0	.....

TABLE 21 (*continued*)

Species inoculated	Mosaic	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
Nicandra Physalodes	A	35	6	B
	B	149	126	B
	C	15	0	.....
	D	16	0	.....
	E	7	0	.....
	F	11	0	.....
	G	7	0	.....
	H	50	18	H
	Checks	65	1	B
Nicotiana glutinosa	A	28	2	1 B 1 Uncertain
	B	62	50	B
	C	26	3	2 B 1 D
	D	37	25	1 B 17 D 7 Uncertain
	E	8	0	.....
	F	13	0	.....
	G	7	0	.....
	H	17	4	H
	Checks	21	0	.....
Nicotiana rustica	A	32	28	A
	B	23	1	A
	C	12	0	.....
	D	11	0	.....
	E	8	0	.....
	F	11	1	A
	G	6	0	.....
	H	15	0	.....
	Checks	23	1	A
Nicotiana Tabacum	A	104	92	A
	B	56	8	A
	C	10	1	A
	D	6	1	A
	E	9	0	.....
	F	3	0	.....
	G	3	0	.....
	Checks	46	3	A

TABLE 21 (*continued*)

Species inoculated	Mosaic	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
Phaseolus vulgaris	A	6	0	.....
	B	6	0	.....
	C	6	0	.....
	D	7	0	.....
	E	2	0	.....
	F	7	0	.....
	G	12	3	G
	H	6	0	.....
	Checks	7	0	.....
Physalis heterophylla	A	7	7	A
	B	8	0	.....
	C	7	0	.....
	D	8	0	.....
	E	3	0	.....
	F	7	1	A
	G	3	0	.....
	H	7	0	.....
	Checks	7	0	.....
Physalis subglabrata	A	23	23	A
	B	24	3	Uncertain
	C	21	0	.....
	D	24	0	.....
	E	21	0	.....
	F	21	6	Uncertain
	G	9	0	.....
	H	21	0	.....
	Checks	23	0	.....
Phytolacca decandra	A	24	0	.....
	B	48	0	.....
	C	16	0	.....
	D	9	0	.....
	E	17	16	E
	F	14	0	.....
	G	5	0	.....
	H	11	0	.....
	Checks	23	0	.....
Rumex obtusifolius	A	18	0	.....
	B	23	0	.....
	C	12	0	.....
	D	15	0	.....
	E	6	0	.....
	F	29	13	F
	G	3	0	.....
	Checks	14	0	.....

TABLE 21 (*continued*)

Species inoculated	Mosaic	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
Solanum aculeatissimum	A	45	39	3 A 36 Uncertain
	B	49	35	2 B 33 Uncertain
	C	21	2	1 A 1 Uncertain
	D	11	0	.....
	E	9	0	.....
	F	12	0	.....
	G	8	0	.....
	H	9	2 (?)	H (?)*
	Checks	29	0	.....
Solanum atropurpureum	A	3	3	A
	B	3	2	B
	C	3	0	.....
	D	3	0	.....
	F	3	0	.....
	H	2	0	.....
	Checks	2	0	.....
Solanum carolinense	A	9	9	A
	B	9	6	B
	C	7	0	.....
	D	8	0	.....
	E	2	0	.....
	F	7	0	.....
	G	3	0	.....
	H	6	0	.....
	Checks	9	0	.....
Solanum Dulcamara	A	9	0	.....
	B	9	0	.....
	C	7	0	.....
	D	8	0	.....
	E	3	0	.....
	F	7	0	.....
	G	3	0	.....
	H	7	0	.....
	Checks	9	0	.....
Solanum nigrum	A	9	5	A
	B	9	1	A
	C	7	0	.....
	D	8	0	.....
	E	3	0	.....
	F	7	0	.....
	G	3	0	.....
	H	7	0	.....
	Checks	9	1	A

* The author was not sure that these plants were affected with mosaic. The symptoms were certainly not those of either mosaic A or mosaic B.

TABLE 21 (*concluded*)

Species inoculated	Mosaic	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
Solanum tuberosum	A	40	24	22 A 2 A and B
	B	74	40	B
	C	2	0	
	D	1	0	
	E	2	0	
	F	2	0	
	G	1	0	
	Rubbed checks	6	0	
	Grafted checks	9	5	4 A 1 B
	Untreated checks	23	0	

INTERPRETATION OF RESULTS

Liability to error

Reasonable precautions were taken to prevent errors. In spite of these, there are evidences in the data that errors did occur. Errors in diagnosis were reduced to a minimum by keeping the plants growing vigorously as much as possible, and discarding doubtful cases. It is very likely that some of the species recorded as not susceptible were carriers without showing symptoms. It was not always found possible to record the type of mosaic present. Errors due to accidental contamination did occur, especially during the early part of the experimental work when the hands were applied to the plants in making inoculations. After this practice was discontinued, very little contamination occurred. Some of the earlier experiments were omitted where there was evidence of contamination. Aphids occasionally became fairly abundant in the greenhouses in spite of frequent fumigation, but apparently they did not cause much natural spread. White flies, thrips, and red spiders were sometimes annoying, but there was no indication that they were ever instrumental in transmitting mosaic.

While accidental infections were not frequent, they occasionally did occur. If, therefore, only three or four plants showed positive results from a given transfer, this cannot be taken as proof that the species is susceptible to that particular virus.

Reliability of numerical results

In interpreting the data, it is felt that too much reliance cannot be placed on numerical results. Consideration must be given also to such matters as the conditions under which the particular results were obtained, and the clearness of the symptoms obtained. For example, the author has no hesitation in stating that *Nicotiana glutinosa* is susceptible to mosaic H, although only four positive cases were obtained out of seventeen plants inoculated. The symptoms were so different from those obtained on this suscept when inoculated with mosaic B or mosaic D, that the positive cases could not be regarded as contaminations. However, no such positive statement can be made concerning mosaic C on this plant. It would appear that the three positive cases obtained with this mosaic were contaminations, although this is by no means certain. Taking all such factors into consideration, table 22 has been prepared to show what interpretation is placed on the data by the author. Doubtless, further work will require changes in the conclusions, particularly with reference to negative results.

TABLE 22. SUSCEPTIBILITY OF SPECIES TO MOSAICS

Species inoculated	Mosaic							
	A	B	C	D	E	F	G	H
Datura meteloides	—	+	+	?	—	—	—	—
Datura Stramonium	—	+	+	?	—	—	—	—
Lycopersicon esculentum	+	+	—	—	—	—	—	—
Martynia louisiana	+	—	..	?	—	—	—	..
Nicandra Physalodes	—	+	—	—	—	—	—	+
Nicotiana glutinosa	—	+	—	+	—	—	—	+
Nicotiana rustica	+	—	—	—	—	—	—	—
Nicotiana Tabacum	+	—	—	—	—	—	—	..
Phaseolus vulgaris	—	—	—	—	—	—	+	—
Physalis heterophylla	+	—	—	—	—	—	—	—
Physalis subglabrata	+	?	—	—	—	?	—	—
Phytolacca decandra	—	—	—	—	+	—	—	—
Rumex obtusifolius	—	—	—	—	—	+	—	..
Solanum aculeatissimum	+	+	—	—	—	—	—	?
Solanum atropurpureum	+	+	—	—	..	—	..	—
Solanum carolinense	+	+	—	—	—	—	—	—
Solanum Dulcamara	—	—	—	—	—	—	—	—
Solanum nigrum	+	—	—	—	—	—	—	—
Solanum tuberosum	+	+	—	—	—	—	—	..

Inoculations from potato

In addition to the data presented in tables 2 to 22, some interesting results were obtained by inoculating various plants with material obtained from potato. These results seem to require special consideration. At various times *Nicandra Physalodes* and *Nicotiana glutinosa* plants were inoculated with leaves from potato plants which were affected with mosaic A. Almost invariably these inoculations gave positive results, although it was found impossible to secure infection with mosaic A when material was taken from species other than potato. At first these positive results were considered as evidence of contamination, but the consistency of the results appeared to indicate some other cause. As a check on these results, inoculations were made with supposedly healthy potatoes. Positive results were obtained also in these cases. To check up on this unexpected development, more extensive inoculations were made. More than a hundred tubers of the Green Mountain variety were used, and the freedom of the potatoes from mosaic was checked by planting the tuber remnants in tuber units out of doors. The results were practically always positive. The data on these inoculations are given separately in table 23:

TABLE 23. INOCULATIONS WITH SOLANUM TUBEROSUM

Species inoculated	Type of symptoms on potato	Number of plants inoculated	Number of plants showing symptoms	Type of symptoms observed
Nicandra Physalodes	A	18	16	B
Nicotiana glutinosa	A	8	6	B
Solanum aculeatissimum	A	2	2	*
Datura Stramonium	None	4	4	B
Nicandra Physalodes	None	55	46	B
Nicotiana glutinosa	None	60	59	B

* The plants appeared to be affected with a mixture of mosaics A and B.

These results are strikingly similar to those recently reported by Johnson (1925). Their exact significance is not clear. Two theories have been suggested to account for this phenomenon. According to one theory, the protoplasm of the potato acts as a pathogene and enters into a kind of symbiotic relation with the protoplasm of the new suscept. This theory is attractive because it suggests an explanation of the etiology of mosaic diseases. The alternative theory is that the potatoes used actually carried a virus; that is to say, they had mosaic although they appeared to be healthy. Schultz and Folsom (1923) have shown that potatoes are subject to at least three mosaics which differ in the readiness with which they can be detected. It is well known that even the more pro-

nounced types of potato mosaic may be masked under some field conditions. Is it not reasonable to suppose that there might be a fourth type of potato mosaic so obscure as to be masked even under the most favorable conditions? Such a mosaic would presumably not have much effect on the yield, and, since it could not be detected by ordinary inspection methods, it would not tend to be eliminated, but, on the other hand, would tend to become universal in a tuber-propagated crop such as the potato. Fields of beans are sometimes seen showing an almost 100-per-cent infection, even though bean mosaic is not 100-per-cent seed-transmitted and though bean mosaic materially reduces the yield.

General results

The most significant feature of the experiments is not a determination of species susceptible to any particular virus, but the fact that different mosaics on the same species exhibit symptoms which are sufficiently different to be easily distinguishable. This is not the first time such a phenomenon has been observed, it having been previously reported by Allard (1916), Jagger (1918), Schultz and Folsom (1923), and Johnson (1925). It is rather surprising that such differences in symptoms have not been reported by other authors who have done extensive cross-inoculation work.

CONCLUSIONS

A comparison of the results of cross-inoculation experiments reported in literature reveals many cases in which the results are in conflict. A review of the literature discloses also the fact that most authors have omitted consideration of a factor here shown to be important, namely, the identity of the mosaic concerned. It has been shown here that a single species may be affected by two or more distinct mosaics, which differ not only in their symptoms but also in their suscept range and probably in other characters as well. It may be that this failure to identify the mosaic concerned accounts for many of the discrepancies found in the literature.

As in the case of diseases caused by bacteria, fungi, and so forth, it is found that some viri are able to produce disease on a wide variety of species distributed in different families, and are at the same time unable to infect species in the same genus as their usual suscepts; while other viri seem to be more restricted in their range of suscepts.

SUMMARY

Inoculation experiments were conducted with mosaics on nineteen species of plants, of which fifteen were Solanaceae. All but one of the species tried were shown to be susceptible to one or more of the mosaics used. It appears that the eight mosaics, which for convenience have been designated by letters A to H, are distinct, with the possible exception

of two, which may prove to be identical. The differences between the mosaics are shown by the species they are able to attack, and by the different symptoms produced by them when inoculated on the same species. They apparently differ also in the ease of inoculation.

Unusual necrotic symptoms not resembling those generally considered characteristic of mosaics, were produced by mosaic A on *Solanum tuberosum* and *Nicotiana rustica.*

The suscept ranges of the mosaics, in so far as they were determined, were as follows:

Mosaic A : *Lycopersicon esculentum, Martynia louisiana, Nicotiana rustica, N. Tabacum, Physalis heterophylla, P. subglabrata, Solanum aculeatissimum, S. atropurpureum, S. carolinense, S. nigrum, S. tuberosum.*

Mosaic B : *Datura meteloides, D. Stramonium, Lycopersicon esculentum, Nicandra Physalodes, Nicotiana glutinosa, Solanum aculeatissimum, S. atropurpureum, S. carolinense, S. tuberosum.*

Mosaic C : *Datura meteloides, D. Stramonium.*

Mosaic D : *Nicotiana glutinosa.*

Mosaic E : *Phytolacca decandra.*

Mosaic F : *Rumex obtusifolius.*

Mosaic G : *Phaseolus vulgaris.*

Mosaic H : *Echinocystis lobata, Nicandra Physalodes, Nicotiana glutinosa.*

Two mosaics were produced on *Datura meteloides, D. Stramonium, Lycopersicon esculentum, Nicandra Physalodes, Solanum aculeatissimum, S. atropurpureum, S. carolinense,* and *S. tuberosum.* Three mosaics were produced on *Nicotiana glutinosa.*

Some of the data appear to indicate that potatoes which are apparently healthy, carry a virus which is able to produce mosaic symptoms when transferred to other species.

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